1. INTRODUCTION

Mixed waste contains both radioactive and hazardous components as defined by the Atomic Energy Act and Resource Conservation and Recovery Act (RCRA), respectively, as well as any radioactive mixture that is contaminated with polychlorinated biphenyls (PCBs). This report addresses only mixed wastes that contain low-level radioactive and RCRA hazardous components and does not address those wastes that contain transuranic, high-level components or PCBs.

The U.S. Department of Energy (DOE) generates large volumes of mixed low-level radioactive waste (MLLW) from environmental restoration, decommissioning, and various ongoing research and defense programs. In addition, DOE has in storage significant volumes of MLLW from past operations. According to the Federal Facility Compliance Act of 1992 (FFCAct), DOE must treat and dispose of MLLW in compliance with Land Disposal Restrictions (LDRs) and other RCRA requirements. MLLW treatment and disposal are expensive and capacities are limited. In fact, significant development of treatment facilities would be necessary to treat the MLLW already in storage. In addition, the costs to treat, store, and handle the low-level radioactive waste (LLW) portion of MLLW are significant, particularly the costs associated with construction, licensing, and permitting of treatment/storage/disposal facilities.

To reduce the personnel and environmental risks and costs associated with the management of MLLW and other wastes, DOE facilities have established waste minimization/pollution prevention (P2) programs. The objectives of these programs follow the U.S. Environmental Protection Agency (EPA) hierarchy, which is to reduce the generation of waste at the source, to reuse or recycle waste that is generated, to maximize the benefits of treatment of wastes that cannot be prevented or recycled, and to identify innovative disposal options that minimize the impact on the environment while minimizing cost.

Although these P2 programs address MLLW, on September 8, 1994, the Defense Nuclear Facilities Safety Board (DNFSB) issued Recommendation 94-2, "Conformance with Safety Standards at DOE Low-Level Nuclear Waste Disposal Sites." This recommendation concluded that DOE's LLW program required improvement. Part of this recommendation calls for "studies of enhanced methods that can be used to reduce the volume of waste to be disposed of..." (Conway 1994). In response to Recommendation 94-2, DOE developed and submitted to DNFSB an Implementation Plan that included plans to "...undertake an evaluation of its current LLW minimization efforts [which will] identify efforts that are successful in reducing the amounts of LLW requiring disposal with the purpose of developing a strategy for extending successful practices to other applications" (DOE 1995h). While MLLW was not specifically addressed in

Recommendation 94-2, DOE has decided to address MLLW as part of its minimization evaluation and strategy for LLW.

In addition, on May 3, 1996, DOE issued a policy statement establishing DOE's P2 goals. This policy statement established a goal for routine waste to reduce total releases and off-site transfers for treatment and disposal of toxic chemicals, including MLLW, based on a 1993 baseline by 50% by 1999.

1.1 OBJECTIVE AND SCOPE

This report presents the results of an evaluation conducted as part of DOE's fulfillment of the commitments made in the Implementation Plan related to LLW reduction. The *Low-Level Radioactive Waste Minimization Evaluation and Strategy* report (DOE/ORO-2043) addresses the minimization of LLW. The objective of this MLLW report is to supplement the LLW minimization recommendations by identifying common MLLW generating activities and developing MLLW minimization recommendations that can be implemented throughout the DOE complex. The findings of this evaluation should also be used to assist DOE sites in reaching DOE's 50% reduction goal for routine MLLW.

For this evaluation, data were collected on MLLW generation processes and minimization approaches that have been implemented at various DOE facilities. Then, MLLW generating activities associated with the minimization approaches were identified, general MLLW minimization options were identified and evaluated, and recommendations for MLLW minimization activities to be implemented throughout the DOE complex were developed. Finally, case studies of approaches that have been implemented were developed to support the recommendations. Appendix A presents detailed MLLW minimization approach data.

The initial data on MLLW generation and minimization approaches were collected for 11 sites:

- Operating sites:
  - Idaho National Engineering Laboratory (INEL)
  - Los Alamos National Laboratory (LANL)
  - Oak Ridge National Laboratory (ORNL)
  - Oak Ridge Y-12 Plant (Y-12)

- Restoration sites:
  - Fernald
  - Hanford
  - Oak Ridge K-25 Site (K-25)
  - Paducah Site (formerly Paducah Gaseous Diffusion Plant)
  - Portsmouth Gaseous Diffusion Plant (Portsmouth)
  - Rocky Flats
  - Savannah River Site (SRS)

The data were primarily collected through a review of annual reports on waste generation and waste minimization, retrieval of information from the Internet FFCAct Bulletin Board, phone interviews with site personnel, and a review of documentation and information provided by site contacts. Waste generation data from annual reports were documented for routine waste and for cleanup/stabilization waste. While both types of waste are generated by almost all DOE facilities, it was established during the LLW minimization evaluation that routine wastes are priority for operating sites, while cleanup/stabilization wastes are priority for restoration sites. However, this report shows that the MLLW generating processes cannot be distinctly identified as routine or cleanup/stabilization related to either operating or restoration sites.

1.2 REPORT CONTENT

The findings of the MLLW evaluation are provided in the following sections of this report. Section 2 presents and evaluates the MLLW generation data for the 11 sites, and Section 3 discusses the MLLW minimization options. Section 4 presents the findings and recommendations of the evaluation of MLLW minimization options. Section 5 presents case studies for each of the recommendations developed by the task team. Section 6 presents a summary of the report. Appendices A through D contain data that supplement Sections 2 through 5.

2. MLLW GENERATION

MLLW generation data from the 11 sites for 1991, 1992, 1993, and 1994 were obtained from annual reports on waste generation and waste minimization. This section describes the reporting categories for MLLW and relates those reporting categories to processes generating MLLW. To the extent possible, generation rates related to each waste category are presented. However, this information is limited because it is not readily available from literature or from site tracking programs.

2.1 METHODOLOGY

The objective of this evaluation was to analyze available data for MLLW generation and identify MLLW generating processes at DOE facilities. The 11 sites previously identified were chosen so that collected data would represent the spectrum of DOE activities, missions, and field offices. They were also chosen because they were among the highest generators of MLLW.

Generation data were primarily collected from the *Annual Report on Waste Generation and Waste Minimization Progress, 1991-1992*, which provides a summary of waste generation for all DOE facilities, and the 1993 and 1994 annual reports on waste generation and waste minimization progress for each of the 11 sites.

For comparative purposes, the 11 DOE sites were subdivided into two groups. The first group currently consists of INEL, LANL, ORNL, and Y-12. These sites are referred to as operating sites. These sites have active, multi-program missions such as basic and applied research laboratories, as well as scientific and engineering capabilities in support of national energy and defense programs. The operating sites also have active restoration and decommissioning programs, but these are not the primary missions at these sites. The second group currently consists of Fernald, Hanford, K-25, Paducah, Portsmouth, Rocky Flats, and SRS. These sites are referred to as the restoration sites. A major part of the mission at these sites is remediation, deactivation, and decommissioning. Although SRS was identified as an operating site in the 1994 annual report, it was established at a previous workshop that SRS had transitioned to primarily a restoration mission. Also, the groupings varied from year to year depending on their site status at the time of reporting. Comparisons were made by site from year to year, among sites within a certain group, and between the two groups.

2.2 MLLW GENERATION DATA

Each site reports its MLLW in six different categories: liquid, solid, inventory, routine, cleanup/stabilization, and process wastewater. These categories are independent of the waste generating process and specific management method for the waste. The latter four terms as used in the annual reports are defined below.

- *Inventory waste* is defined as the total amount of waste in inventory at a site packaged for treatment, storage, and disposal, including wastes generated in all previous years.

- *Routine waste* is defined as waste produced from any type of production, analytical, and/or research and development laboratory operations; treatment, storage, and disposal operations; “work for others”; or any other periodic and recurring work considered ongoing in nature.

- *Cleanup/stabilization waste*[1] is defined as one-time operations waste, such as wastes produced from restoration activities, including primary and secondary wastes associated with retrieval and remediation operations; “legacy wastes”; and decommissioning/transition operations.

- *Process wastewater* is any water produced during manufacturing or processing operations that comes into direct contact with or results from the production or use of any new material, intermediate product, finished product, by-product, or waste product. This determination is independent of the level and/or nature of the contaminants.

For the purposes of this report, the quantity of the liquid plus the solid waste is equal to the quantity of routine plus cleanup/stabilization waste. The liquid plus the solid plus the process wastewater quantities equals the total MLLW generated for a given year. The inventory amount is independent of the total quantity listed.

Generation data for 1991 and 1992 were reported only as liquid and solid MLLW volumes. Annual reports for 1993 and 1994 contain more descriptive information with regard to the different categories of MLLW, such as MLLW inventories, routine MLLW, cleanup/stabilization MLLW, and process wastewater. Tables 2.1 through 2.4 summarize this information by year (1991, 1992, 1993, and 1994) for each facility. These tables identify sites as operating or restoration based on information in the annual reports, which identified them as having a mission of Defense Programs (DPs) (operating site) or Environmental Management (EM) (restoration site). The data in Tables 2.1 through 2.4 are presented graphically in Appendix B.

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[1]This waste includes waste generation from remediation activities.

Table 2.1. MLLW generated or in inventory at 11 DOE sites—CY 1991[a]

	1991 MLLW volumes (m^3)					
	Liquid	Solid	Inventory	Routine	Cleanup/ stabilization	Process wastewater
Operating sites						
INEL	0	52	NR	NR	NR	NR
LANL	0	170	NR	NR	NR	NR
ORNL	9	10	NR	NR	NR	2,049
Paducah	0	137	NR	NR	NR	NR
Portsmouth	221	645	NR	NR	NR	NR
Rocky Flats	0	554	NR	NR	NR	NR
SRS	0	33	NR	NR	NR	NR
Y-12	2,757	734	NR	NR	NR	NR
Restoration sites						
Fernald	0	81	NR	NR	NR	NR
Hanford	1,178	581	NR	NR	NR	NR
K-25	56,931	209	NR	NR	NR	NR
Total	63,132	2,987	NR	NR	NR	NR

aData shown in this table represents waste generated by Defense Programs, Environmental Management, Energy Research, and Nuclear Energy

Table 2.2. MLLW generated or in inventory at 11 DOE sites—CY 1992[a]

	1992 MLLW volumes (m^3)					
	Liquid	Solid	Inventory	Routine	Cleanup/ stabilization	Process wastewater
Operating sites						
INEL	0	93	NR	NR	NR	NR
LANL	0	81	NR	NR	NR	NR
ORNL	3	9	NR	NR	NR	1,524
Paducah	0	824	NR	NR	NR	NR
Portsmouth	386	353	NR	NR	NR	NR
SRS	0	20	NR	NR	NR	NR
Y-12	1,724	481	NR	NR	NR	NR
Restoration sites						
Fernald	0	141	NR	NR	NR	NR
Hanford	2,415	440	NR	NR	NR	NR
K-25	77,697	265	NR	NR	NR	NR
Rocky Flats	0	440	NR	NR	NR	NR
Total	83,744	2,873	NR	NR	NR	NR

DOE = U.S. Department of Energy
INEL = Idaho National Engineering Laboratory
LANL = Los Alamos National Laboratory
MLLW = mixed low-level radioactive waste
NR = not reported
ORNL = Oak Ridge National Laboratory
SRS = Savannah River Site

aData shown in this table represents waste generated by Defense Programs, Environmental Management, Energy Research, and Nuclear Energy

Table 2.3. MLLW generated or in inventory at 11 DOE sites—CY 1993[a]

	1993 MLLW volumes (m^3)					
	Liquid	Solid	Inventory	Routine	Cleanup/ stabilization	Process wastewater
Operating sites						
INEL	0	8	1,140	7	2	0
LANL	0	45	1,160	45	0	0
ORNL	4	8	69	20	1	1,524
Portsmouth	374	1,146	10,000	626	894	11,112
SRS	115	18	3,110	NR	133	0
Y-12	219	290	11,900	410	98	11,140
Restoration sites						
Fernald	16	11	3,110	25	3	126,000
Hanford	3,760	1,500	3,100	4,223	1,040	2,100
Paducah	122	89	1,170	176	35	0
K-25	803	278	27,400	763	318	85,600
Rocky Flats	0	489	3,090	489	0	0
Total	5,430	3,874	65,249	6,784	2,524	497,952

aData shown in this table represents waste generated by Defense Programs, Environmental Management, Energy Research, and Nuclear Energy.

Table 2.4. MLLW generated or in inventory at 11 DOE sites—CY 1994[a]

	1994 MLLW volumes (m^3)					
	Liquid	Solid	Inventory	Routine	Cleanup/ stabilization	Process wastewater
Operating sites						
INEL	1	344	78,400	23	322	0
LANL	0	76	665	26	49	0
ORNL	13	5	36	123	2	2,113
SRS	738	3	3,410	741	0	0
Y-12	156	105	17,100	241	20	10,900
Restoration sites						
Fernald	47	35	2,520	2	80	0
Hanford	2,500	2,310	3,870	570	1,73740	0
K-25	6,980	222	35,700	504	6,694	85,100
Paducah	0	82	3,760	0	83	0
Portsmouth	1,460	327	4,710	0	1,787	0
Rocky Flats	21	267	3,580	275	13	NR
Total	11,906	3,778	153,751	4,890	10,788	98,180

DOE = U.S. Department of Energy
INEL = Idaho National Engineering Laboratory
LANL = Los Alamos National Laboratory
MLLW = mixed low-level radioactive waste
NR = not reported
ORNL = Oak Ridge National Laboratory
SRS = Savannah River Site

aData shown in this table represents waste generated by Defense Programs, Environmental Management, Energy Research, and Nuclear Energy.

Because it is optional to report process wastewater generation, "0" entries for process wastewater may represent either actual zero generation or simply a lack of reporting. However, because the reporting of all other MLLW is required, the zeros in this category should actually represent zero. As shown in Tables 2.1 through 2.4, all 11 DOE sites reported some type of MLLW from 1991 to 1994.

The MLLW generation rate is based on the volume of waste received into treatment, storage, and disposal facilities within the given calendar year. This generation rate does not take into account those wastes being held at satellite storage facilities. Therefore, the annual generation rate is not necessarily correlated to process generation rates since MLLW is transferred to the storage and disposal facilities in batches.

2.3 MLLW GENERATING PROCESSES RELATED TO WASTE REPORTING CATEGORIES

The annual reports do not provide data that directly relate waste generating rates to individual processes. However, descriptions of waste minimization activities presented in the reports indicated the general types of processes that generated MLLW and presented significant minimization potential. A description of each of these generating processes is necessarily intertwined with a discussion of the steps taken to minimize MLLW generated by these processes. Hence, process descriptions are provided in Section 3 as waste minimization approaches are discussed. As demonstrated in Section 3, the identified MLLW minimization approaches can be related back to four major waste generating activities: laboratory activities, equipment maintenance, facility maintenance, and waste management. These activities are primarily associated with routine waste reporting.

2.4 FEDERAL FACILITY COMPLIANCE ACT-RELATED WASTE GENERATION

The FFCAct ended DOE's sovereign immunity from fines and penalties under the provisions of RCRA. At the time the FFCAct was passed and signed, MLLW in storage at DOE sites was generally not in compliance with RCRA mixed waste LDRs because of a lack of treatment capacity in the government and private sectors. Recognizing this lack of treatment capacity, the FFCAct delayed by 3 years (until October 6, 1995) the imposing of any fines or penalties related to the storage of mixed waste. During the 3-year hiatus, DOE was required to prepare and obtain regulatory approval for Site Treatment Plans (STPs) for choosing treatment technologies, developing the needed treatment capacity, and treating the mixed waste at any site where DOE generated or stored mixed wastes. DOE has 35 STPs and associated compliance orders covering 38 sites. Three of the sites involved in this study—K-25, ORNL, and Y-12—were combined into one STP for the Oak Ridge Reservation. One of the study sites, Hanford, was not required to prepare a STP because it was subject to a Tri-Party Agreement with the State of Washington that already addressed mixed waste treatment. Each of the other sites in this study submitted its own STP.

In addition to approval by state or EPA regulators, the process of developing and submitting STPs was open to public participation. Members of the public were notified of draft STP availability and were given opportunities to comment to DOE and/or the regulators. A bulletin board of information about the FFCAct and DOE's compliance with it is available on the Internet through the EM homepage. In addition to reports and notices, the Mixed Waste Inventory Report (MWIR) and its 1995 database are available through the Internet. MWIR contains information about the physical, chemical, and radiological composition of each mixed waste stream at each DOE site. Administrative and possible treatment information are also available in MWIR. With few exceptions, each of these stored waste streams must be treated according to the approved site Implementation Plan.

Total volumes of MLLW in storage at each site (as of 1994) identified in the 1995 MWIR database are given in Table 2.5. The total volume of all waste streams is 109,762 m^3. If the total is reduced by the volume of treated (stabilized) sludge in storage at K-25 (15,400 m^3), the remaining total volume to be treated is 94,361 m^3. DOE (1995) estimates that the total volume of MLLW in storage and projected to be generated in the next 5 years is 128,664 m^3 at all DOE sites combined. Hence, the volume of waste in storage at the study sites represents a substantial portion of the total volume of MLLW requiring treatment.

Table 2.5. Mixed waste volumes in storage based on FY 1995 data

Site	Waste volume in storage (m^3)
Fernald	2,151
Hanford	6,330
INEL	25,440
K-25	29,473[a]
LANL	609
ORNL	2,997
Paducah	1,032
Portsmouth	7,515
Rocky Flats	13,550
SRS	7,200
Y-12	13,465

[a]Includes 15,400 m^3 of treated pond sludge that is ready for disposal.

3. MLLW MINIMIZATION OPTIONS

This section describes the methods and resources used to collect MLLW minimization approach data and annual waste reduction data, the approaches implemented that contributed to those reductions, and the relationship of the approaches to the processes generating the waste. As presented in Section 2, the priority waste for operating sites is routine waste, while the priority waste for restoration sites is cleanup/stabilization waste. For cleanup/stabilization activities, many of the same processes [personal protective equipment (PPE) use, investigation, restoration, and decommissioning] that generate LLW will also generate MLLW, depending on what the materials are contaminated with at the site/facility. Therefore, some of the same recommendations made for restoration facilities for LLW may also be applicable for MLLW. Additional information supporting the MLLW minimization recommendations can be found in Section 5 (Case Studies) and Appendix A. Section 5 and Appendix A data support the recommendations and provide additional information on the implementability of the recommended options. However, whether a site is operating or in restoration mode, the MLLW generating activities (laboratory activities, equipment maintenance, facility maintenance, and waste management) that are identified here will apply to all DOE facilities to some degree.

The DOE/ORO-2043 report identified the following activity-specific LLW minimization recommendations for operating sites and restoration sites:

- Operating sites:
  - Suspect waste—down posting and controlled entry
  - PPE use—segregation and entry restrictions
  - Effluent treatment—procedural changes and carbon regeneration
  - Miscellaneous—segregation for volume reduction

- Restoration sites:
  - Remediation activities—reuse and leave in place
  - Decommissioning—recycle/reuse and free release
  - Site investigation—revise techniques and revise decontamination procedures

These options for LLW may also be applicable for MLLW if the contaminant of concern is hazardous (i.e., making it MLLW) rather than LLW. For example, if a piece of PPE comes in contact with a medium that is contaminated with a radioactive constituent only, the PPE would be considered LLW. If that same piece of PPE comes in contact with a medium that is contaminated with a radioactive constituent **and** a hazardous constituent, the PPE would then be considered MLLW. However, the same options identified for LLW PPE can also be applied to MLLW PPE.

In addition to the above recommendations identified in the DOE/ORO-2043 report, the options described in Section 3.2 of this report can also be implemented at either operating or restoration sites to help reduce MLLW generation.

3.1 METHODOLOGY

The initial objective of the evaluation was (1) to identify the MLLW minimization approaches that have been implemented at DOE facilities and the processes or activities affected by the approach and (2) to evaluate the success and general applicability of the approach. General descriptions of the approaches were initially collected from the annual reports for each of the 11 sites chosen for the study. These reports provided brief descriptions of the waste minimization approaches implemented. The descriptions include the approach taken, the activity or process affected, the waste stream affected, and the quantity of waste reduction realized. In addition, the 1994 reports provided some data on the time, investment, and cost savings associated with implementing the approach. Information for other DOE sites was included when it was appropriate and readily available. This information is presented in detail in Appendix A.

The MLLW generating processes were defined by identifying those processes affected by the reported MLLW minimization approaches. Although the list of MLLW generating processes in this report may not be comprehensive, it is considered to represent the processes with the most potential for minimization based on the success of the waste minimization activities implemented thus far.

3.2 MLLW APPROACHES FOR GENERATING PROCESSES

This section discusses MLLW generating processes and corresponding MLLW minimization options. Additional information can be found in Section 5 and obtained from site contacts listed in Appendix C. For the purpose of this report, waste minimization approaches and waste minimization options are defined as follows:

- waste minimization approach: a specific waste minimization activity that took place at a specific site (e.g., replace tape with Velcro strap at Hanford laboratory) and

- waste minimization option: a general method for achieving waste minimization, which may represent multiple site reported approaches (e.g., equipment modification).

3.2.1 Site-Level Options for Minimizing MLLW

Three options identified for MLLW should be applied at the site level and will affect the greatest number of MLLW streams generated by each site. These are:

- administrative approaches,
- chemical traffic controls, and
- down posting.

While these options are considered priority, the options listed in Section 3.2.2 should also be reviewed and considered for DOE sites to which they have applicability.

3.2.1.1 Administrative activities

To minimize future generation of incidental or secondary mixed waste from mixed waste treatment activities, restoration projects, or other planned activities, planning strategies can be effective in significantly reducing future generation of MLLW. These strategies were identified and developed from reports of successful approaches and some input from site management and DOE personnel.

After reviewing the annual reports, four administrative approach strategies were identified—planning/policy, organization, awareness/training, and tools development/information exchange. Each of these approaches are discussed in more detail below.

Planning/Policy. Planning/policy options could be implemented to be instrumental in reducing the future generation of mixed waste. The general options presented in Table 3.1 were identified in the annual reports.

Table 3.1. Planning/Policy options for MLLW minimization

Option	Number of sites reporting
Develop plans to minimize overall waste generation and establish waste generating baselines and goals	5
Establish policy changes within programs that will impact and reduce waste generation	3
Initiate PPOAs for some programs	1

MLLW = mixed low-level radioactive waste
P2 = pollution prevention
PPOA = Pollution Prevention Opportunity Assessment

Any waste management or waste generating program should have measurable waste reduction goals established and documented in their respective overall program plans. Establishing a mixed waste generation baseline from which to measure waste reduction progress would be an excellent starting point to give personnel a quantitative way to measure and monitor progress.

Establishing and implementing waste minimization policy guidance for future and existing programs is another good approach. One very good policy that could have an impact on future mixed waste generation is the requirement for waste generators to prepare and submit a plan prior to the actual generation of waste, such as that reported in the 1994 annual report for Portsmouth. This approach would require personnel to plan and think through projects before embarking on waste generating activities.

Another good approach to reduce the future generation of mixed waste is to conduct Pollution Prevention Opportunity Assessments (PPOAs) for needed activities. By conducting PPOAs, ways to reduce or eliminate waste streams can be identified and the findings incorporated into planning.

Numerous planning/policy approaches have been identified and could be applied to reduce the generation of future mixed waste as shown in Table A.1 in Appendix A.

Organization. Table 3.2 lists general organizational options that have been implemented and could be used at other DOE sites to reduce the future generation of mixed waste.

Table 3.2. Organizational options for MLLW minimization

Option	Number of sites reporting
Include waste minimization or P2 personnel on project teams	3
Create waste minimization committees and appoint full-time waste minimization/P2 coordinator	2

MLLW = mixed low-level radioactive waste
P2 = pollution prevention

The organizational options include forming committees to assist in identifying waste minimization opportunities and, as was identified in the LLW study, including P2 or waste minimization personnel on project teams. Placing P2 or waste minimization personnel on project teams ensures that P2 and waste minimization issues get addressed early in the project. A report (Burns 1995) prepared by LANL discuss the merits of placing P2 personnel on projects. In addition, committees or teams could be formed to evaluate MLLW generating activities and identify potential ways to eliminate or reduce the waste. By identifying these issues early, waste generation may be eliminated or the potential quantity of waste generation reduced. This option could definitely reduce the future generation of both MLLW and LLW. Table A.1 in Appendix A lists these approaches.

Awareness/Training. Implementing awareness/training programs is one of the more popular ways to reduce or eliminate the generation of waste, although it is difficult to conduct awareness training for waste generation activities. While there are numerous approaches listed (see Table A.1 in Appendix A), four common themes are listed in Table 3.3.

Table 3.3. Awareness/training options for MLLW minimization

Option	Number of sites reporting
Sponsor P2 awareness weekly/monthly celebrations	6
Publicize and encourage participation in recycling programs	4
Establish award and incentive programs	3
Establish general P2 or waste minimization training	11

MLLW = mixed low-level radioactive waste
P2 = pollution prevention

The most frequently reported option for encouraging waste minimization is training. All sites in the study reported some type of training program, ranging from a basic awareness module included in General Employee Training (GET) to project-specific training on how to implement source reduction. Training programs are to some degree an extension of the awareness programs, in that training makes personnel aware of current P2 initiatives and approaches they can use to prevent pollution and generate less waste. Training is developed and presented based on the level of personnel involved. A broader type of training is presented to the management level than is presented to shop level personnel. Management is presented with training that gives them a broad picture of what P2 is and how to implement P2 ideas at the shop level. Shop personnel are presented with a more streamlined, detailed type of training to help them evaluate their specific task and find ways to eliminate or reduce waste produced from their task.

Publicizing and encouraging participation in recycling programs is another prevalent option. While this is not a form of source reduction, it is a form of P2 and it encourages people to evaluate the waste they are generating and hopefully find a way to recycle or reuse the waste to make it in to a usable product. This approach would only work for MLLW if segregation is used to remove the hazardous waste component.

Sponsoring P2 awareness either in the form of a week- or month-long celebration with activities that encourage and teach personnel about P2 options is also a good approach. By showing people how P2 can affect not only their work but also how it affects their families and communities, a greater impact can be achieved, and in turn, hopefully, a higher awareness is gained.

Tools Development/Information Exchange. Table 3.4 lists tools development/information exchange options that have been implemented at various sites to reduce the future generation of mixed waste. These options are based on computerized database tracking or sharing P2 or waste minimization opportunities with other sites or companies.

Table 3.4. Tools development/information exchange options for MLLW minimization

Option	Number of sites reporting
Establish a computerized system for tracking waste or P2 project status	5
Develop process waste assessment (similar to PPOA) methodology	1
Meet with area companies to benchmark P2 programs and projects	1
Conduct special studies on alternate disposal practices	1

MLLW = mixed low-level radioactive waste
P2 = pollution prevention
PPOA = Pollution Prevention Opportunity Assessments

Databases that either assist in tracking the progress of P2 options or waste minimization PPOAs may not assist in actually reducing waste generation, but they are good tools for analyzing and tracking waste reduction.

Software tools and general methodology guidance can be used during the planning stages of projects for option analysis and cost benefit analysis to help choose how to do a project. An example of this is the “Decision Methodology for Fernald Scrap Metal Disposition Alternatives” report. The methodology was divided into two phases: the life cycle analysis and the decision phase.

Information exchange approaches were documented at one site. This site implemented approaches, such as meeting with area companies to benchmark P2 opportunities, and conducted some special studies on alternatives to existing disposal practices. Information obtained from these benchmarking meetings and special studies were shared within their organizations and with other sites.

3.2.1.2 Chemical traffic controls

MLLW by definition (see Section 2) requires the presence of a hazardous component. One way to minimize the generation of MLLW is to eliminate the use of the hazardous substance or find a substitute for the hazardous material. This may be accomplished effectively by implementing a chemical traffic control system. A chemical traffic control system includes specific waste minimization activities like material substitution programs and a hazardous material control tracking system.

Table 3.5 presents the two major MLLW minimization options that have been implemented to prevent the introduction of a hazardous component to an otherwise non-hazardous (and, therefore, non-mixed) radioactive waste at the 11 sites in this study.

Table 3.5. Waste minimization options reported for hazardous material use

Option	Number of sites reporting	Total reduction
Substitute non-hazardous material for hazardous material	5	166 m^3
Eliminate use of the hazardous material	2	1.1 m^3

Several sites reported unique instances of substituting a non-hazardous material for a hazardous material to reduce MLLW generation in a contamination area. All products containing hazardous constituents should be evaluated prior to use in a contamination area (e.g., substitute a non-hazardous paint stripper for a hazardous one). In addition, some sites identified specific opportunities to eliminate the use of the hazardous material (e.g., replacing a tank of methylene chloride with an ultrasonic cleaner using non-hazardous detergent). Regardless of use, when a hazardous chemical is stored in a contamination area and its shelf-life expires, it must then be disposed of as MLLW. Therefore, hazardous chemicals should not be stored in contaminated areas.

Although these approaches can be very effective when applied to only one specific activity, they can be implemented more effectively through a central organization responsible for identifying substitution and elimination opportunities and overseeing storage and chemical issuing practices. Implementation of a chemical traffic control system would ensure the evaluation of chemical purchases and reduce MLLW by identifying non-hazardous substitutes and controlling the quantities issued.

A detailed list of approaches reported in the annual reports is presented in Table A.2 in Appendix A.

3.2.1.3 Down posting

This option was identified in the DOE/ORO-2043 report but is discussed again in this report due to its applicability to MLLW and significant success where it has been implemented. Just as preventing the introduction of a hazardous component to an otherwise LLW prevents MLLW generation, so will the prevention of the potential introduction of a radioactive component to an otherwise RCRA hazardous waste.

DOE Order 5400.5 states that any property "shall be considered to be potentially contaminated if it has been used or stored in radiation areas that could contain unconfined radioactive material or that are exposed to beams of particles capable of causing activation." Suspect waste is generated in a radiological area; it is usually not economically feasible to ascertain by radiological monitoring, process knowledge, or sampling and analysis that the material does not contain radiological contamination. Requirements for the release of materials and equipment from radiological areas to other controlled areas are given in 10 Code of Federal Regulations 835.1101.

Furthermore, if the waste is known to originate from an area outside a designated Radioactive Material Management Area (RMMA), the waste can be classified as nonradioactive. DOE's Oak Ridge Y-12 Plant has taken an approach toward establishing, certifying, and maintaining non-RMMA (Procedure Y70-308, October 6, 1994). Wastes originating from these areas are, by definition, not radioactive. Hence, the production of suspect MLLW can be reduced by reducing the size and/or throughput of hazardous materials in known RMMAs or, if an approach similar to Y-12 is taken, maximizing the size and throughput of non-RMMAs.

MLLW reduction can be accomplished by reducing the hazardous waste generated in a contamination area, preventing hazardous materials from entering the contaminated area, or down posting areas from contamination to radiation or clean areas so that materials entering the area will not be considered suspect when they leave the areas. These approaches have proven to be very effective and implementable. This option has been implemented with much success at Y-12, SRS, Hanford, and INEL.

3.2.2 Activity-Specific Options

In addition to the site level options identified above and discussed in the DOE/ORO-2043 report, the following MLLW options may be more applicable to specific sites and activities and not necessarily to all DOE sites. It is recommended that the following options be reviewed (laboratory activities, equipment maintenance, facility maintenance, and waste management) and implemented if applicable to the site.

3.2.2.1 Laboratory activities

The generation and minimization of MLLW associated with laboratory activities is discussed in this section. For this study, “laboratory” is either an analytical, research, or photographic lab.

Laboratory Activities MLLW Generation. Waste generating activities for this study included any type of activity that takes place within a laboratory setting. Activities that generate waste include the use of laboratory reagents that become mixed with a radioactive component or cleaning radioactively contaminated laboratory equipment. Laboratory waste is common to most DOE facilities.

Laboratory Activities MLLW Minimization. Laboratory-generated MLLW can be reduced through the chemical controls discussed above. Table 3.6 presents the two other MLLW options that have been implemented to reduce laboratory-generated waste at the sites in this study.

Table 3.6. Waste minimization options reported for laboratory activities

Option	Number of sites reporting	Total reduction
Modify laboratory equipment	3	9.1 m^3
Reuse or recycle laboratory material	2	4.6 m^3

The majority of options implemented to reduce the generation of laboratory MLLW involve modification of laboratory equipment. If existing laboratory equipment can be modified or if new equipment is available that eliminates the need for a hazardous component, then the equipment should be either modified or replaced (e.g., placing Velcro straps on laboratory equipment to replace the use of strapping tape to hold samples in place while mixing).

Another option is to reuse or recycle material used in the laboratory (e.g., recycle and reuse the acid for cleaning glassware). However, in these cases, the reusable material may only be considered MLLW because it is classified as suspect waste. When reusing potentially radioactively contaminated material, careful consideration should be given to the possibility of cross-contamination (see Section 3.2.1 of DOE/ORO-2043).

A detailed list of approaches reported in the annual reports is presented in Table A.3 in

Appendix A.

3.2.3 Equipment Maintenance

This section discusses the options for minimization of waste associated with equipment maintenance.

Equipment Maintenance MLLW Generation. MLLW is generated when maintenance is performed on equipment located in a radiological area or if maintenance is performed and the hazardous waste comes in contact with any contamination. One major way waste is generated is when fluids are changed out on equipment. The hazardous fluids sometimes become contaminated with radioactive materials, thus making them a mixed waste. Equipment maintenance activities that generate mixed waste are common to most DOE facilities.

Equipment Maintenance MLLW Minimization. Table 3.7 presents two MLLW options that have been implemented to reduce the generation of MLLW from equipment maintenance at sites in this study.

Table 3.7. Waste minimization options reported for equipment maintenance

Option	Number of sites reporting	Total reduction
Modify equipment	4	20 m^3
Reuse or recycle fluids used in equipment	1	1 m^3

The main approach identified in this option involves the modification of existing equipment (e.g., installing a filtration system on chillers to eliminate the need to annually change out oil, eliminating the generation of waste oil contaminated with freon). Another approach identified was to recycle or reuse some fluids that are removed from the equipment. One standard fluid that is typically reused/recycled is ethylene glycol. However, in these cases, the reusable material may only be considered MLLW because it is classified as suspect waste. When reusing potentially radioactively contaminated material, give careful consideration to the possibility of cross-contamination (see DOE/ORO-2043).

A detailed list of approaches reported in the annual reports is presented in Table A.4 in Appendix A.

3.2.4 Facility Maintenance

This section discusses the generation and minimization of MLLW associated with facility maintenance activities.

Facility Maintenance MLLW Generation. Facility maintenance activities include cleaning floors, changing filters, painting, remodeling, or other activities necessary to maintain an operational facility. For example, spills on the floor due to either process tank overflows or machinery leaks (e.g., contaminated oil leaks) must be cleaned up with some type of absorbent material. Spills in dike areas must be pumped out or drained to an area and cleaned up. If the spill contains hazardous constituents and occurs in a radiological area, the spilled material and cleanup material are MLLW.

Other types of MLLW generation come from changing air filters. Most buildings have an air filtration system that uses some type of filter to purify or take contaminants out of the air. These filters must be changed periodically and may be classified as MLLW if used to filter air in a radiological area with a hazardous component (i.e., mercury contamination area). Facility maintenance activities that generate MLLW are common to most DOE facilities.

Facility Maintenance MLLW Minimization. Table 3.8 presents three MLLW options that have been implemented at some of the study sites in order to reduce the generation of facility maintenance waste.

Table 3.8. Waste minimization options reported for facility maintenance

Option	Number of sites reporting	Total reduction
Modify process or a piece of equipment within the facility	3	0.3 m^3
Treat waste within the facility	1	3.4 m^3
Reuse or recycle material within the facility	1	3.7 m^3

Approaches that could reduce the amount of waste generated from facility maintenance activities are generally associated with either process modifications located within the building or to equipment that is located within the building. Processes that take place within a building may involve the use of tanks. Spills from these tanks could be eliminated by modifying the equipment to eliminate the possibility of an overflow. One process modification is to eliminate the floor sweep waste from spill cleanup (e.g., terminate the use of saw dust and oil as a dust suppressant for floor sweeping of mixed waste).

Another way to minimize MLLW is to neutralize it, thereby removing the characteristic that makes it hazardous. In-place neutralization also reduces the cost to collect, transport, and store the waste.

Reusing or recycling cleaning or maintenance chemicals will also reduce facility maintenance MLLW (e.g., settle and reuse paint thinner in a contaminated area). If the solutions can be recycled or reused, the need to bring additional chemicals into the area is eliminated. However, in these cases, the reusable material may only be considered MLLW because it is classified as suspect waste. If the material were truly radioactively contaminated, reuse would not be technically appropriate.

A detailed list of approaches reported in the annual reports is presented in Table A.5 in Appendix A.

3.2.5 Waste Management

This section discusses the generation and minimization of waste associated with waste management activities. Waste management includes treatment, storage, disposal, and all other associated activities.

Waste Management MLLW Generation. Waste generated from waste management activities typically is divided into three areas—treatment, storage, and disposal. All three of these activities result in incidental wastes, such as PPE, from waste handling. Treatment activities normally generate a secondary waste stream, such as wastewater treatment sludge (see discussion in Section 3.3.1). Storage and disposal activities require the sampling and characterization of waste, which results in sample material and incidental wastes (e.g., gloves, bags, decontamination water, and paper). Waste management activities generating MLLW are common to most DOE facilities.

Waste Management MLLW Minimization. Table 3.9 presents six MLLW options that have been implemented to reduce the amount of waste generated from waste management activities.

Table 3.9. Waste minimization options reported for waste management

Option	Number of sites reporting	Total reduction
Reuse or recycle chemicals used in process	5	761 m^3
Modify processes to eliminate waste	2	10.2 m^3
Segregate waste to reduce volume	2	126 m^3
Divert stormwater to prevent it from entering contaminated areas	2	79.4 m^3
Modify equipment	5	250 m^3
Treat waste	1	1.3 m^3

As shown in Table 3.9, reuse and recycling of material (e.g., excess chemicals from a cleanup project were reused in biodenitrification and bio-oxidation processes) are the leading methods used across the DOE sites to reduce waste management related waste generation.

Modification of an existing process can reduce the amount of MLLW waste generated. For example, if sampling of each waste container is necessary, increasing the size of storage/transport tanks can reduce the number of samples taken, thereby reducing a related waste. Also, if appropriate, permits can be modified to allow material to be stored longer, thereby reducing the frequency of emptying large capacity tanks, which may be only half full at the end of 90 days.

Segregation of waste offers opportunities for reducing the amount of waste to be stored and treated. Characteristically hazardous waste can potentially be removed from MLLW containers to result in one hazardous waste stream and one LLW stream (less expensive than MLLW). This does require some additional labor if the waste is already drummed or stored. The key is to integrate segregation as a practice at the beginning of a project. This will allow the segregation to occur as the project progresses, not at the end [e.g., segregated hazardous component (lighter, aerosol can, etc.) from LLW containers]. Segregation is typically easier to conduct at the beginning of a project; however, benefits can also be gained by conducting it at the end.

The diversion of stormwater run-off prevents it from mixing with other wastes and reduces the quantity of waste generated. If stormwater does not enter tanks that contain mixed waste, the amount of water that has been diverted will not become a mixed waste. These modifications can include altering the slope of an asphalt pad, rerouting plant roof drains, and diverting stormwater around and away from contaminated areas.

Once again, modification of equipment or a process can also reduce the amount of waste generated. Various types of modifications can be applied to a process or a piece of equipment to reduce the generation of MLLW waste (e.g., installing a “Brine Cell” to oxidize a solution rather than adding a chemical that results in eight times the volume of waste).

Waste may also be prevented by using in-stock chemicals to neutralize the waste to the extent possible, preventing the need to dispose of the excess in-stock chemicals when they have passed the expiration date and if they are stored in a radiation area.

A detailed list of approaches reported in the annual reports is presented in Tables A.6 and A.7 in Appendix A.

3.3 MLLW MINIMIZATION FOR PLANNED WASTE GENERATING ACTIVITIES

3.3.1 Treatment of Stored Wastes in Compliance with FFCAct

As shown in Section 2.4, the 11 study sites had over 94,000 m^3 of MLLW in storage at the end of CY 1994. These wastes must be treated in accordance with the provisions of Mixed Waste Treatment Compliance Plans that have been approved by EPA or the site's host state to avoid fines and penalties associated with RCRA. Treatment may be on-site in currently existing, proposed, or vendor-supplied systems; off-site at another DOE facility; or off-site at a commercial facility. "Treatment" in practically all cases means treatment of the RCRA-regulated component of the waste to meet LDRs or to destroy the hazardous characteristic. Treatment can be expected to produce incidental wastes that may be LLW or MLLW, such as PPE, discarded used parts or liners, or decontamination streams (liquids and sludges) associated with routine maintenance. These incidental wastes can be minimized by using approaches and recommendations developed and discussed in the DOE/ORO-2043 report.

General categories of MLLW treatment processes and their associated secondary wastes are shown in Table 3.10. Secondary wastes will be either MLLW themselves or LLW. Hence, proper planning is necessary to ensure that the volume of secondary waste is minimized for any treatment process. In addition, it should be noted that some treatment processes, such as cementation of sludges or debris, may result in significant volume increases of waste forms requiring disposal. Furthermore, the output of a treatment process may require further treatment (e.g., incinerator ash may require stabilization).

Table 3.10. MLLW treatment processes and associated secondary wastes

Treatment process category	Potential secondary waste
Physical/chemical treatment of wastewaters and aqueous slurries	Sludges, filter cakes, spent resins
Stabilization	Wastewater
Organic destruction	Wastewater, fly ash, baghouse bags
Inorganic debris treatment	Wastewater
Alkali metal deactivation	Wastewater, sludge
Pyrophoric/explosive deactivation	Wastewater, ash
Mercury separation	Organics
Soil washing	Wastewater

4. EVALUATION OF MLLW MINIMIZATION OPTIONS AND RECOMMENDATIONS

This section presents an evaluation of the MLLW minimization options presented in Section 3.3 and the recommendations developed from that evaluation. This evaluation was accomplished through a meeting with internal project personnel and additional input from site personnel. The objective of the evaluation was to develop MLLW minimization recommendations that can be implemented at numerous DOE facilities. The three options that were identified as priority for site level implementation (administrative activities, chemical traffic controls, and down posting) were not evaluated.

4.1 METHODOLOGY

The evaluation was performed by project personnel who brought experience from a similar evaluation performed for LLW at a one-day workshop attended by representatives from DOE-HQ and DOE and contractor personnel from seven DOE sites. (The LLW workshop is described fully in the DOE/ORO-2043 report.) The team reviewed a comprehensive table of MLLW generating processes and potential minimization options. The team also discussed criteria by which to evaluate the approaches and ranked the approaches for each generating category. The information used in the DOE/ORO-2043 evaluation are presented in Appendix D. The team then discussed the MLLW generating categories and evaluated corresponding waste minimization options. Evaluation criteria included the following:

- economic feasibility,
- quantity of reduction,
- quantity of generation,
- technical risk,
- EPA hierarchy,
- compliance, and
- application potential.

Each minimization option received a score of 1, 2, or 3 for each criterion, with 1 representing the least desirable option for that criterion, 2 representing an acceptable option, and 3 representing the most desirable option for that criterion. Table 4.1 shows the evaluation criteria, the scores, and rationale associated with particular rankings.

Table 4.1. Evaluation criteria and ranking rationale

	Score			
	1	**2**	**3**	
Economics	High investment; low savings	High investment/ high savings or low investment/low savings	Low investment/ high savings	Rankings were relative within each generating category
Reduction	Low reduction	High reduction	Eliminated	Rankings were relative within each generating category
Generation	Affects small waste stream	Affects medium waste stream	Affects large waste stream	Rankings were relative within each generating category
Technical risk	Great risk of not working as intended	Probably will work to some extent	Likely will work as expected or better	Rankings were consistent among all generating categories. A ranking of 3 was consistent among all generating categories because all options have been implemented and no technical risk was perceived
EPA hierarchy	Treatment or disposal	Reuse/recycle	Source reduction	Rankings were consistent among all generating categories. Each option was ranked based on whether it involved treatment or disposal, reuse/recycle, or source reduction
Compliance	Non-compliant	Compliant but requires DOE Order change to implement or modification of existing permits	Compliant	Rankings were consistent among all generating categories. As a general rule, a score of 3 was assigned to most options. The two exceptions will be discussed in their relevant sections
Potential	Limited applicability across DOE	Useful to approximately 50% of DOE sites	Useful to most DOE sites	Rankings were relative within each generating category

4.2 SITE LEVEL RECOMMENDATIONS

Three recommendations were recognized and were found to be applicable. These three recommendations are:

- administrative,
- chemical traffic controls, and
- down posting.

These recommendations were generally applicable to all sites and were recommended without further evaluation.

4.3 ACTIVITY-SPECIFIC OPTIONS

Table 4.3 is a summary of the MLLW activity-specific generating categories and corresponding MLLW minimization options. For consistency, the evaluation of MLLW minimization options followed the same methodology used for the LLW evaluation. The results of the evaluation are presented in the following sections.

Table 4.3. Generating processes

Generating process	Options
Laboratory activities	Equipment modification Reuse
Equipment maintenance	Equipment modification Material reuse
Facility maintenance	Process modification Reuse
Waste management	Sampling modification Waste segregation Stormwater diversion Equipment modification Treatment modification Reuse

4.3.1 Laboratory Activities

Two potential options were identified for laboratory activities: equipment modification and reuse. The results of the evaluation are presented in Table 4.3.

Table 4.3. Options for laboratory activities

	Option priority ranking		
	Equipment modification	**Reuse**	
Economics	1	2	Equipment modification has a potentially large investment and will receive moderate savings; reuse does not require a large investment and would receive the same moderate savings
Reduction	2	1	Equipment modification option has potential to reduce a larger volume of waste than reuse
Generation rate	2	2	Both options affect a medium size waste stream
Technical risk	3	3	Options have been implemented and no technical risk was identified
EPA hierarchy	3	2	Each option was ranked based on whether it involved treatment or disposal, reuse/recycle, or source reduction
Compliance	3	3	Options are compliant
Potential	1	3	Reuse is implementable at more DOE facilities; equipment modification is more site-specific and may not generally apply to all sites
Total	**15**	**16**	

4.3.2 Equipment Maintenance

Two potential options were identified for the equipment maintenance generating process: equipment modification and material reuse. The results of the evaluation are presented in Table 4.4.

Table 4.4. Options for equipment maintenance

	Option priority ranking		
	Equipment modification	**Material reuse**	
Economics	2	2	Both have perceived equal investment and savings potential
Reduction	3	2	Equipment modification could potentially eliminate the waste, whereas material reuse has a high reduction potential
Generation rate	2	1	Equipment modification could eliminate a medium waste stream, whereas reuse only has a small waste stream it could eliminate
Technical risk	3	3	Options have been implemented and no technical risk was identified
EPA hierarchy	3	2	Each option was ranked based on whether it involved treatment or disposal, reuse/recycle, or source reduction
Compliance	3	3	Options are compliant
Potential	2	2	Material reuse and equipment modification would be equally useful to approximately 50% of the DOE sites
Total	**18**	**15**	

4.3.3 Facility Maintenance

Three potential options were identified for the facility maintenance generating process: process modification, material reuse, and treatment. The results of the evaluation are presented in Table 4.5.

Table 4.5. Options for facility maintenance

	Option priority ranking			
	Process modification	**Material reuse**	**Treatment**	
Economics	2	3	2	Material reuse has a low cost and moderate savings, whereas process modification and treatment would require more money to implement with only moderate savings
Reduction	2	2	2	All options could potentially reduce a high quantity of waste
Generation rate	2	3	2	Process modification and treatment has the potential to eliminate a large waste streams versus material reuse, which has a limited waste stream it could affect
Technical risk	3	3	3	Options have been implemented and no technical risk was identified
EPA hierarchy	3	2	1	Each option was ranked based on whether it involved treatment or disposal, reuse/recycle, or source reduction
Compliance	3	3	3	Options are compliant
Potential	2	2	2	All options would be equally useful to approximately 50% of the DOE sites
Total	**17**	**18**	**15**	

4.3.4 Waste Management

Six potential options were identified for waste management activities: sampling modification, waste segregation, storm water diversion, equipment modification, treatment modification, and reuse. The results of the evaluation are presented in Table 4.6.

Table 4.6. Waste management options

4.4 MLLW MINIMIZATION RECOMMENDATIONS

In addition, after evaluating the activity-specific MLLW minimization options using the described criteria, the team determined that all options are recommended. This decision was based on the numbers generated from evaluating the MLLW minimization options. The rankings of the options were so close that is was decided that none of the options would be discarded.

In addition, administrative, chemical traffic control, and down posting are recommended as priority for site level implementation.

The next section presents case studies that support these recommendations. The case studies contain information for individual sites to make a determination if the option recommended is appropriate or applicable for their site.

5. MLLW MINIMIZATION CASE STUDIES

The objective of this section is to present sufficient information for the MLLW minimization options recommended in Section 4 to help DOE sites determine whether an option identified is feasible for their site. This section presents case studies developed to help illustrate how some of the recommendations in Section 4 have been implemented at various DOE sites. The case studies are based on data obtained from site contacts at several DOE facilities.

At least one case study is presented for each of the four generating categories identified for MLLW. In addition, one case study is presented for chemical traffic controls. Case studies for down posting are presented in the LLW report (DOE/ORO-2043) and are not repeated here. The case study presents a baseline of the existing data, briefly describes the MLLW minimization approach that was applied, and then discusses the results of the project. When available, the cost to implement the option as well as the cost savings and the waste reduction amount are also given.

5.1 OBJECTIVE AND METHODOLOGY

The objective of this activity was to develop case studies that verify the implementability and applicability of the MLLW minimization recommendations developed in Section 4 and to provide some insight on implementation issues to assist other DOE sites in identifying where and how to implement the suggested recommendations.

Projects to potentially use as case studies were identified from annual reports and discussions with site representatives. The appropriate site personnel were contacted for information in addition to that found in the annual reports. The primary contact for each recommendation is listed in Appendix C. This list provides contacts that may be useful for obtaining additional information or answering questions about their successes or failures in implementing MLLW minimization options.

5.2 MLLW MINIMIZATION CASE STUDIES

There were four waste generating categories identified for MLLW. They include laboratory activities, equipment maintenance, facility maintenance, and waste management. Also, a case study is presented for chemical traffic controls. A case study for down posting is presented in DOE/ORO-2043 and is not repeated here. A summary of that case study is presented in Table 6.1.

5.2.1 Chemical Traffic Controls

The case study for this recommendation was implemented at SRS.

Contact. Keith Stone; (803) 557-6317

Baseline. In December 1994, the SRS established and fully staffed a Chemical Commodity Management Center (CCMC). The commodity management center is a site organizational tool used to provide a central, focused approach for the acquisition, inventory control, and distribution and redistribution of materials/equipment used throughout the site. The site recognized that with greater than 50,000 chemical materials and greater than 10,000 products requiring Material Safety Data Sheets increased management control would offer the opportunity for significant reductions in chemical procurement and associated waste management and P2.

MLLW Minimization Approach. The CCMC began accepting chemicals in April 1995. The CCMC is recognized as “the source” for chemicals at the site. Twenty-eight just-in-time contracts have been awarded. These type contracts significantly reduce on-site chemical inventories, avoid expiration of chemical shelf-life, and reduce liabilities associated with warehousing chemicals. Also, an on-line, real-time chemical tracking system was implemented. A more streamlined procurement procedure and reduced procurement cycle time for 8000 chemicals was also established. This streamlined approach essentially eliminated routine CCMC reviews for a wide variety of chemicals.

Results. This MLLW minimization activity achieved a cost avoidance of greater than $250K in 1995 for excess chemical redistribution on-site and off-site. In the last quarter of CY 1995, the CCMC received greater than 9000 lb of chemicals into excess and dispersed greater than 7500 lb of chemicals for reuse in lieu of disposal.

5.2.2 Laboratory Activities

The recommendations identified for laboratory activities were equipment modification and reuse. The case studies for these recommendations are presented below.

5.2.2.1 Equipment modification

At Hanford, a project was implemented to install Velcro straps on a Chemical Vortex Shaker.

Contact. Mary Betsch; (509) 372-1627

Baseline. Before samples can be subdivided for various analytical tests, they must be vortexed (shaken vigorously) for a specified amount of time to ensure homogeneity. The design of the laboratory equipment does not accommodate the variety of glass vial sizes used in laboratories, so the chemists used green industrial strength tape to secure the vials.

MLLW Minimization Approach. The green industrial strength tape was replaced with a reusable and adjustable Velcro strap. The velcro strap is used to secure glass vials to the laboratory equipment. This approach eliminated 1.5 rolls of green tape used daily.

Results. This MLLW minimization activity reduced the amount of solid MLLW, primarily tape, by 0.6 m^3 annually. Annual cost savings from the purchase and disposal of tape totaled $46,193. The cost to implement this approach was $172.00.

5.2.2.2 Reuse

At Y-12, a project was implemented to reuse the acid for cleaning laboratory glassware. This reuse project was associated with suspect waste and is, therefore, not specific to MLLW. Refer to Section 5.2.1 of the DOE/ORO-2043 report for other approaches related to eliminating the suspect classification of waste.

Contact. Shelia Poligone; (423) 241-2568

Baseline. Various laboratories at Y-12 use acid for cleaning/leaching glassware, which is discarded after one use.

MLLW Minimization Approach. Acid for cleaning laboratory glassware is recycled and used for cleaning.

Results. This MLLW minimization activity reduced the amount of liquid MLLW waste by 4.13 m^3. Annual cost savings was approximately $82,000. Also, an unquantifiable amount was saved procuring supplies, mixing acid solutions, and disposing of wastes. The cost to implement this approach is not available.

5.2.3 Equipment Maintenance

The two recommendations for maintenance on equipment are equipment modification and material use. The case studies for these recommendations are presented below.

5.2.3.1 Equipment modification

There were two case studies identified for equipment modification (one for SRS and one for Y-12).

Contact. Keith Stone; (803) 557-6317

Baseline. The Dilute Effluent Treatment Facility (DETF) is an end-of-pipe industrial wastewater treatment facility that uses precipitation and filtration. The wastewater is pressure filtered through a Tyvek filter media. The Tyvek media is a disposable sub-micron media that is used only once in the filtration cycle. After the filtration cycle is completed and the filter cake discharged, the Tyvek is re-rolled and then discarded to a B-25 metal 90-ft^3 storage box as a listed F006 mixed waste.

MLLW Minimization Approach. To eliminate the single-use Tyvek filter paper, a very tight weave fabric belt that is flushed by an air/water spray after the filter cake discharges was needed. A national search was conducted, and a new filter aid manufacturer that consistently achieved the stringent DETF acceptance criteria was identified. Eight different sub-micron filter belt fabrics were tested in DETF process simulations. Approval to perform full-scale demonstration on three of the belts was obtained and approval to convert to the cleanable belts was obtained.

Results. This MLLW minimization approach achieved a 93% reduction in mixed waste generation, primarily the elimination of filter paper rolls, by 289 ft^3/year. The DETF routinely generated 2.6 mixed waste used filter paper rolls per batch. As of February 1993, the DETF has two more years of supernate processing. If the conversion to the cleanable belts did not occur, DETF would have generated 15 B-25 boxes of mixed waste (1350 ft^3). By converting to the cleanable belts, the used filter paper waste stream has been greatly reduced. Only one box of B-25 waste, versus 15, will be generated in 2 years of operation. A total cost savings of $360,000 was realized. The cost to implement this approach, including research and development, totaled $50,000.

Another project involving equipment modification was also implemented at Y-12.

Hydraulically driven centrifuges were replaced with electrically driven units. This MLLW minimization approach reduced the amount of MLLW by approximately 200 gal/year of waste hydraulic oil. The annual cost savings, assuming $7/gal to treat the hydraulic oil, is estimated to be $1400. Implementation costs are not available.

5.2.3.2 Material reuse

At Y-12, a project was implemented to recycle ethylene glycol. This reuse project was associated with suspect waste and is, therefore, not specific to MLLW. Refer to Section 5.2.1 of the DOE/ORO-2043 report for other approaches.

Contact. Shelia Poligone; (423) 241-2568

Baseline. Ethylene glycol is used in various pieces of equipment at Y-12. The ethylene glycol is periodically drained from equipment during servicing.

MLLW Minimization Approach. The ethylene glycol drained from equipment being serviced at Y-12 is later placed back into the equipment.

Results. The MLLW reduction achieved, the annual cost, and the implementation cost are not available.

5.2.4 Facility Maintenance

The recommendations identified for facility maintenance were process modification and reuse. The case studies for these recommendations are presented below.

5.2.4.1 Process modification

At ORNL, a project was implemented to reduce the number of filter change-outs in Building 4508. **Contact.** Susan Michaud; (423) 576-1562

Baseline. Building exhaust filters make up a significant part of hazardous waste for the Metal & Ceramics Division located in Building 4508. A team was chartered to develop recommendations to ensure that hazardous waste in the form of building exhaust filters is minimized to the extent possible. Building 4508 is a two-floor building with 150 people evenly distributed between the two floors. The energy consumption for Building 4508 totals about 40,000 MBtu/year, with about

80% being used for heating, ventilation, and air-conditioning. Prior to 1990, the filters were changed out annually regardless of their condition. Starting in 1990, the filters have been changed out when the filter becomes loaded with particulate matter.

MLLW Minimization Approach. Based on the study, the team recommended the following activities:

- perform a detailed survey of building ductwork to determine whether current high-efficiency particulate air (HEPA) filters are necessary;
- evaluate the results of the detailed study;
- replace HEPA filters with less expensive filters, based on the technical approval of the results of the evaluation;
- implement variable-speed fan control;
- perform an engineering evaluation of rebalancing air flow; and
- consider implementing a laboratory policy that requires installation of local HEPA filtration as an integral part of laboratory equipment.

Results. The MLLW minimization approach resulted in the reduction of about 500 ft^3 in 1992. An annual cost savings of $180,000 was estimated. The implementation cost of $150,000 included labor to test laboratory hoods.

5.2.4.2 Reuse

A project at ORNL involved the reuse of paint thinner. The case study for this recommendation is presented below. This reuse project was associated with suspect waste and is, therefore, not specific to MLLW. Refer to Section 5.2.1 of the DOE/ORO-2043 report for other approaches.

Contact. Susan Michaud; (423) 576-1562

Baseline. Paint thinner was used daily for a large project at ORNL.

LLW Minimization Approach. The paint thinner was allowed to settle out and was then reused.

Results. The MLLW reduction achieved was 1000 gal and a cost savings of $40,000 was realized. The cost of implementation was not available.

5.2.5 Waste Management

The six recommendations developed for waste management are sampling modification, waste segregation, stormwater diversion, equipment modification, treatment modification, and reuse. The case studies for these recommendations are presented below.

5.2.5.1 Sampling modification

The Hanford site implemented a project that involved modifying a Part A permit to allow longer storage times.

Contact. Mary Betsch; (509) 372-1627

Baseline. The T-Plant helps facilities reuse equipment by offering decontamination services for items such as gas cylinders, trucks, and railcars. Tanks at the T-Plant were emptied every 90 days, regardless of the volume, resulting in additional PPE waste, rinsate, and decontamination materials.

MLLW Minimization Approach. The T-plant revised its Part A permit to allow for the storage of waste. As a result, rather than emptying the tank system every 90 days regardless of the volume, waste is allowed to accumulate until the tank system is full. Final approval for the Part A permit revision will not occur until 1999.

Results. This MLLW minimization approach reduced the amount of MLLW, primarily PPE, rinsate, and decontamination materials, by 7.6 cm^3. An annual cost savings of $200,000 was realized. The cost to implement this approach was $40,000.

5.2.5.2 Waste segregation

The Hanford site implemented a project to reduce the waste designation of some waste from MLLW to LLW.

Contact. Mary Betsch; (509) 372-1627

Baseline. Thirty-three boxes located at the Tank Farm contained some type of material that prevented the waste from being classified as LLW.

MLLW Minimization Approach. The 33 boxes at the Tank Farm were sorted and the material that kept it from being classified as MLLW was removed and disposed of as LLW. This changed the waste designation from MLLW to LLW.

Results. The MLLW minimization approach resulted in the reduction of 119.5 m^3 of waste. A net annual savings of $354,800 was realized. The cost to implement this approach was <$100.

5.2.5.3 Stormwater diversion

Y-12 implemented a project to reduce the amount of rainwater accumulation, thereby reducing the volume of treatable wastewater.

Contact. Shelia Poligone; (423) 241-2568

Baseline. The Oak Ridge area experiences an average annual rainfall of 56.5 in. and evaporative loss of 24 in. There are 15 dikes and tanker-trailer staging areas within the Y-12 Plant western exclusion area. The practice is to pump the dikes after significant rains, which reduces the impact of evaporative losses by an estimated 50%. The removed water attributed to rainwater accumulation is estimated conservatively at 38,300 ft^3. This potential occupies a minimum of fifty-eight 5000-gal tanker-trailer transfers per year.

MLLW Minimization Approach. This project proposed to install sheltering canopies over the 15 dikes and tanker-trailer staging areas. This project anticipates reducing the volume of treatable chemical and/or radiation wastewater, attributed to collected rainwater, at the 15 existing liquid collection sites by 287,000 gal/year. This will further reduce the resource burden for sampling, pumping, pre-treatment storage, and hauling, thus reducing the number of tanker-trailers and personnel engaged in liquid waste handling.

Results. This MLLW minimization activity reduced the amount of MLLW, primarily stormwater run-off, by 287,000 gal/year. An annual cost savings from reduced disposal costs totaled over $1,704,000. The cost to implement this approach is not available.

5.2.5.4 Equipment modification

Hanford implemented a project to reduce the waste flush water from a railcar loading operation.

Contact. Mary Betsch; (509) 372-1627

Baseline. The existing railcar system at the 340 Facility is awkward and does not provide adequate controls to meter the water used during operations. This operation is performed approximately every 90 days.

MLLW Minimization Approach. An upgrade to the 340 Facility is planned. The upgrade will provide on-demand pressurized water with standard control valves that optimize the amount of flush water used.

Benefits. This MLLW minimization activity may eliminate 400 L of mixed waste during railcar transfer. Annual cost savings were $4400 and the implementation cost was $2500.

5.2.5.5 Treatment modification

The SRS implemented a project to neutralize waste using in-stock chemicals.

Contact. Keith Stone; (803) 557-6317

Baseline. Zinc bromide and other chemicals are located at various sites at SRS.

MLLW Minimization Approach. Chemicals currently in stock at SRS were used to neutralize existing waste. This allowed the waste to be disposed of as LLW versus MLLW and reduced in-stock unused chemicals.

Results. This MLLW minimization approach annually reduced the amount of MLLW, primarily waste acids. The cost to implement this approach, including manpower to neutralize the waste, is $1,000–$10,000. The annual cost savings is not available.

5.2.5.6 Reuse

Y-12 implemented a project to reuse lead for shielding.

Contact. Shelia Poligone; (423) 241-2568

Baseline. No baseline is available.

MLLW Minimization Approach. The lead was reused during evaporator restart.

Results. This MLLW minimization activity eliminated 50 ft^3 of MLLW. Annual cost savings and the cost to implement this approach are not available.

Table 6.2

Table 6.1

6. SUMMARY

MLLW generation and waste minimization data were collected from 11 DOE facilities, including both operating facilities and restoration facilities. Initial waste minimization options that were identified as priority to keep LLW and hazardous waste segregated (in an effort to prevent MLLW from being generated) and to improve future operations were (1) administrative activities, (2) chemical traffic controls, and (3) down posting. Table 6.1 presents case study information for these priority recommendations. Note that the down posting case study information is obtainable from the DOE/ORO-2043 report.

Evaluation of the collected data determined that four major MLLW generating activities presented minimization potential. They are listed below:

- laboratory activities;
- equipment maintenance;
- facility maintenance; and
- waste management.

These activities were found to be common to most DOE sites, regardless of whether they are operating or restoration sites. MLLW minimization options were identified for the generating activities and were evaluated based on a specific set of criteria. Based on the evaluation of the MLLW minimization options, the difference in the scores for the MLLW minimization options was insignificant. Therefore, all the options are recommended and none were eliminated.

Table 6.2 summarizes the information in this report for each recommendation developed for the operating sites and restoration sites. The table presents some indication of the ease of implementation, general applicability, and level of technology development. The case study results, waste reduction, and economic benefit potential for each recommendation are also presented in summary form.

In addition to these recommendations, note that multiple other approaches are reported in annual reports and recommended in PPOA reports, as summarized in Section 3 and Appendix A. Approaches recommended in these reports should also be considered when evaluating MLLW minimization activities.

Table 6.1. Priority recommendations for MLLW minimization case study results

Generating category	Recommended option	Approach[a]	Case study results	
			Reduction	Potential cost savings
Chemical traffic control	Comprehensive chemical traffic control system	17	16,500 lb/year	$250,000/year
Administrative down posting	No case study			
Down posting[b]	Down posting laboratory building	13	441,180 lb/year	$1,000,000/year

[a]The number of times each recommendation was reported as an implemented approach in annual reports and other site data.

[b]Information from DOE/ORO-2043.

Table 6.2. Recommended MLLW options and corresponding case study results

Generating category	Recommended option	Approach[a]	Case study results: Reduction	Case study results: Potential cost savings	Case study results: Implementation cost
Laboratory activities	Equipment modification	4	0.6 m^3year	$46,193/year	$172
	Reuse	2	4.1 m^3/year	$82,000/year	NA
Equipment maintenance	Equipment modification	4	1,350 ft^3	$360,000/year	$50,000
	Material reuse	1	NA	NA	NA
Facility maintenance	Process modification	4	500 ft^3	$180,000	$150,000
	Reuse	1	1,000 gal	$40,000	NA
Waste management	Sampling modification	2	7.5 m^3	$200,000	$40,000
	Waste segregation	2	119.5 m^3	$354,800	<$100
	Reuse	6	50 ft^3	NA	NA
	Stormwater diversion	3	287,000 gal/year	$1,704,000	NA
	Equipment modification	2	400 L/year	$4,400	$2,500
	Treatment modification	4	201 ft^3/year	NA	$1,000–$10,000

NA = not available

[a]The number of times each recommendation was reported as an implemented approach in annual reports and other site data.

7. BIBLIOGRAPHY

Barkenbus, B. D. and E. F. Thomas 1994. "Oak Ridge K-25 Site 1993 Annual Hazardous Waste Reduction Progress Report," March 1994.

Burns, M. 1995. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Los Alamos National Laboratory*, October.

Conway, John T. 1994. Recommendation 94-2 to the Secretary of Energy, "Conformance with Safety Standards at DOE Low-Level Nuclear Waste Disposal Sites," September 8.

Radian International 1996. *Low-Level Radioactive Waste Minimization Evaluation and Strategy*, DOE/ORO-2043, August.

DOE 1993. *1994 Annual Report of Waste Generation and Pollution Prevention Progress*, August.

DOE 1994a. *Annual Report on Waste Generation and Waste Minimization Progress, 1991-1992*, DOE/S-0105, February.

DOE 1994b. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge Y-12 Plant*, October.

DOE 1994c. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Fernald Environmental Management Project*, November.

DOE 1994d. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Los Alamos National Laboratory*, November.

DOE 1994e. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge K-25 Site*, November.

DOE 1994f. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Portsmouth Gaseous Diffusion Plant*, November.

DOE 1995a. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Hanford Site*, January.

DOE 1995b. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Idaho National Engineering Lab*, January.

DOE 1995c. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge K-25 Site*, January.

DOE 1995d. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge National Lab*, January.

DOE 1995e. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Paducah Gaseous Diffusion Plant*, January.

DOE 1995f. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Rocky Flats Environmental Technology Site*, January.

DOE 1995g. *1993 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Savannah River Site*, January.

DOE 1995h. *Implementation Plan: Conformance with Safety Standards at Department of Energy Low-Level Nuclear Waste and Disposal Sites*, March 31.

DOE 1995i. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Hanford Site*, DOE/RL-95-84, September.

DOE 1995j. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Paducah Site*, September.

DOE 1995k. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge K-25 Site*, October.

DOE 1995l. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge Y-12 Plant*, October.

DOE 1995m. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Portsmouth Gaseous Diffusion Plant*, October.

DOE 1995n. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Rocky Flats Environmental Technology Site*, October.

DOE 1996. *Decision Methodology for Fernald Scrap Metal Disposition Alternatives*, January.

FERMCO 1995. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Fernald Environmental Management Project*, October.

Ivey, G. A. 1995. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Oak Ridge National Lab*, October.

Griffin, J. D. 1995. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Idaho National Engineering Lab*, November.

Westinghouse Savannah River Company 1995. *1994 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1, Savannah River Site*, November.